11. Yaroslav

Program Name: Yaroslav.java Input File: yaroslav.dat

Yaroslav is currently alone in his spacecraft, engines off due to a malfunction, drifting in space. You are a programmer at NASA tasked with predicting Yaroslav's location as he drifts so that you can help others determine if he is in any danger! You know Yaroslav's current position in space (using x,y,z coordinates) and you know his trajectory (the velocity he has in the x-direction, the y-direction, and the z-direction. You also have a catalog of all the celestial bodies whose gravitational effects will affect Yaroslav's rocket. Luckily, you have a physicist friend who has given you some kinematic equations to help you determine how gravity will affect Yaroslav.

F = GMm/r^2
Force_x = GMm/r^2*(Position_x - Planet_x)/r
Force_y = GMm/r^2*(Position_y - Planet_y)/r
Force_z = GMm/r^2*(Position_z - Planet_z)/r
Acceleration_x = Force_x/m
Acceleration_y = Force_y/m
Acceleration_z = Force_z/m
Velocity_NEW_x = Acceleration_x * t + Velocity_x
Velocity_NEW_y = Acceleration_y * t + Velocity_y
Velocity_NEW_z = Acceleration_z * t + Velocity_z
Position_NEW_x = Velocity_NEW_x * t + Position_x
Position_NEW_y = Velocity_NEW_y * t + Position_y
Position_NEW_z = Velocity_NEW_z * t + Position_z
r = distance between Yaroslav and the Body.
m = 160000 kg (Mass of spacecraft)
M = mass of the Body (in kg)
G = 0.0000000006674 N m^2/kg^2 (Newton's gravitational constant)
t = timestep faction (1/1000 s)

For this problem, use a t value of 1/1000. This means that if you want the values to all of these equations at 20 seconds in the future, that you will need to update these equations 20 * 1/t = 20000 times.

For example, if Yaroslav is at position (0, 0, 0) with an initial velocity of (0, 0, 0), and there is only one celestial body: a planet with mass 59721986000000000000000000.0 kg at position (100000000.0, 100000000.0, 100000000.0), then the first calculation will be to determine the forces generated by this planet in all directions affecting Yaroslav's spacecraft. This calculation is shown below for the x variable, and would be similar for the y and z variables.

Force_x = G * (59721986000000000000000000.0 kg) (160000 kg) / ((173205000.0 m)^2) * (100000000.0 m)/(173205000.0 m) = 1227 N.

Next we use this Force to determine the acceleration:

Acceleration_x = (1227 N) / (160000 kg) = 0.007669 m/s^2

Then we use this Acceleration to determine the new Velocity:

Velocity_NEW_x = (0.007669 m/s^2) * (1/1000 s) + (0 m/s) = 0.000007669 m/s

Finally we use this new Velocity to determine Yaroslav's new Position:

Position_NEW_x = (0.000007669 m/s) * (1/1000 s) + (0 m) = (0.000000007669 m)

Now we have new values for Yaroslav's position & velocity, thus his distance to all the celestial bodies has changed, so you must do all of these calculations again. This is how much his position has changed in 1/1000 th of a second, so, you must repeat this n*1000 times to determine his position in n seconds.

Please help ensure Yaroslav's safety by writing a program to do these crucial calculations!

Input: The first integer will represent the number of data sets to follow. For each data set, the first line will be Yaroslav's initial position. The second line with be Yaroslav's initial velocity in the x, y, and z directions. The third line will be how many seconds in the future we need to know Yaroslav's position and total velocity. The fourth line will be the number of celestial bodies, p, whose gravity are going to affect Yaroslav. The next p lines will be sets of 4 doubles, the first representing the mass of the object (in kg) the next 3 representing the x, y, and z position of the object in space.

Output: Each data set should display the sentence "**`YAROSLAV IS AT POSITION (x, y, z).`**" where x, y, z represent the x, y, and z coordinates of Yaroslav.

Assumptions: Yaroslav will never fall within 500 m of a celestial body. All positions are given in meters. You'll never be asked to predict his safety more than 2 minutes in the future.

Sample Input:

```
3
0.0 0.0 0.0
2.0 2.0 2.0
60
1
597219860000000000000000.0 100000000.0 100000000.0 100000000.0
0.0 0.0 0.0
0.0 0.0 0.0
60
2
597219860000000000000000.0 100000000.0 100000000.0 100000000.0
597219860000000000000000.0 100000000.0 -100000000.0 -100000000.0
1.0 7.0 6.0
5.0 5.0 5.0
30
3
59721986000000000000.0 100000.0 200000.0 300000.0
59721986000000000000.0 3000000.0 2000000.0 1000000.0
59721986000000000000.0 200000.0 300000.0 100000.0
```

Sample Output:

```
YAROSLAV IS AT POSITION (-18.08, -18.08, -18.08).
YAROSLAV IS AT POSITION (-478.31, -0.00, -0.00).
YAROSLAV IS AT POSITION (-14164.83, -17573.83, -10698.49).
```